

Formulation of Microstripline Characteristics Impedence, Phase Velocity and Guide Wavelength

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Abstract: The planar Transmission Lines are: Stripline, Microstripline, Slot line, Coplanar Striplines & their different variant forms such as inverted and suspended striplines & microstriplines etc. Among these microstripline is the most suited due to its open structure, low losses in gigahertz range of frequency, reduced size, improved reliability and eventual cost reduction in mass production. The microstrip transmission line consists of a narrow strip conductor separated from a conducting ground plane by an intervening supporting dielectric substrate as studied by Wheeler and others [1, 2].

Keywords: Phase Factor, MIC's, Filter, Transmission line

1. Introduction

The electromagnetic traveling through such structures suffers from some losses like: Conductor loss & Dielectric loss. There is a change of phase of the wave traveling through the structure also. This phase change (shift) depends on the width of metal strip, height of the dielectric substrate, permittivity of the substrate and operating frequency. The present study is devoted to this objective i.e. we have to study the variation of Phase-Shift of the wave within the structure with width of the stripline, height & effective permittivity of the structure & frequency [3, 4, 5].

Microwave Integrated circuits (MIC'S) have changed these systems in the present days by replacing large scale waveguides and co-axial component arrays to small light weight assemblies. These introduced microwave striplines, microslotlines, coplanar strip lines and coplanar waveguide etc. The design system used for these circuits has also changed from the early "cut & try" methods, using "ruler and knife" to the computer aided design (CAD), photo-mechanical fabrication and optical fiber communication. The transmission lines, waveguide, co-axial cable, stripline and micro striplines are used for sending message signals from one place to another. Striplines and micro striplines are planer transmission structures having features as : Small in size, Low cost, Light weight, and Easily replaceable are widely used these days. Microstripline is an open structure and used in microwaves integrated circuits. There are various parameters like characteristics impedance, phase velocity, guide wavelengths and propagation parameters. These parameters are very sensitive to the frequency in the microwave region. These also depend on the geometry of the structure. The aim of the present work is to concentrate on the study of the Phase Shift of the microstripline structure with frequency, width and height of the structures comprising its geometry.

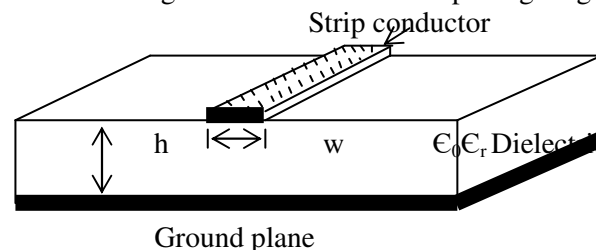


Fig 1: Microstripline (QUASI-TEM Mode)

It is out of various planer transmission structures microstripline is an important open structure. It consists of a narrow conductor strip on one side of a dielectric substrate and the other side being completely metalized to serve as a ground plane. Although the structure is open, the radiation problem is avoided by using high dielectric constant substrate. Alumina ($\epsilon_r=9.6$) and garnet etc are most commonly used substrate. In the present paper we use garnet having dielectric constant $\epsilon_r=10.5$.

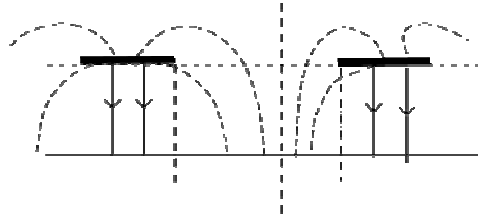


Fig 2: The even mode forward coupling

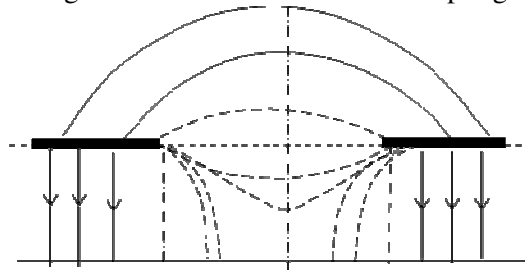


Fig 3: The odd mode reverse coupling

2. Materials and Methods

2.1 Formulation of Characteristics Impedence

The transmission structures like two parallel wire transmission line, co-axial cable, waveguide, stripline, microstripline, slotline and their different variants posses the different characteristics parameters like characteristics impedance, propagation constant, phase velocity and guide wavelength. All these parameters are the function of the width of the metal strips, height of the dielectric substrates and permittivity of these substrates. Here we concentrate only for the study of characteristics impedance and their variation with strip width, height and operating frequency of the wave to be propagated through the transmission structure. The characteristic impedance [6,7] of TEM transmission line like stripline and microstripline is given by

$$Z_0 = 1/V_p C_p \quad 1$$

Where, V_p = phase velocity of the wave traveling along the transmission structure.

C_p = capacitance per unit length of the structure.

C_p is given by the expression

$$C_p = (\epsilon_r / C\eta) (w/h) + (2/3) (\epsilon_r / C\eta) (w/h) (\epsilon_r / C\eta) \cdot (2.7 / \text{Log} 4h/t) \quad 2$$

and Characteristics Impedence is giver by

$$Z_0 = (\eta / \sqrt{\epsilon_{re}}) [1 / [(w/h) + (2w/3h) + (2.7 / \text{Log} 4h/t)]] \quad 3$$

Were w = width of microstripline, h = height of dielectric substrate, t = thickness of stripline and ϵ_r =permittivity of the dielectric substrate.

2.2 Formulation of Phase Velocity and Guide Wavelength

When a microwave source is connected to the stripline wave starts flowing. The velocity with which the wave propagates is called phase velocity which is the function of geometry of the stripline, height of the dielectric substrate and effective permittivity[8]. The relation between phase velocity and effective permittivity is given for TEM mode as

$$V_p = c / \sqrt{\epsilon_{re}} \quad 4$$

Where, c = velocity of the wave in free space= 3×10^8 m/sec

If λ_0 is free space wavelength and λ_g is the Guide wavelength than If λ_g is given by the relation

$$\lambda_g = \lambda_0 / \sqrt{\epsilon_{re}}$$

Where $\sqrt{\epsilon_{re}}$ is the effective permittivity of the dielectric substrate used in the microstripline structure.

2.3 Study of Phase Shift (β)

The Phase shift of a microstripline structure is important characteristic that indicate the phase change of the wave traveling through the microstripline structure[9]. It is denoted by Phase factor

$$\beta = 2\pi/\lambda_g$$

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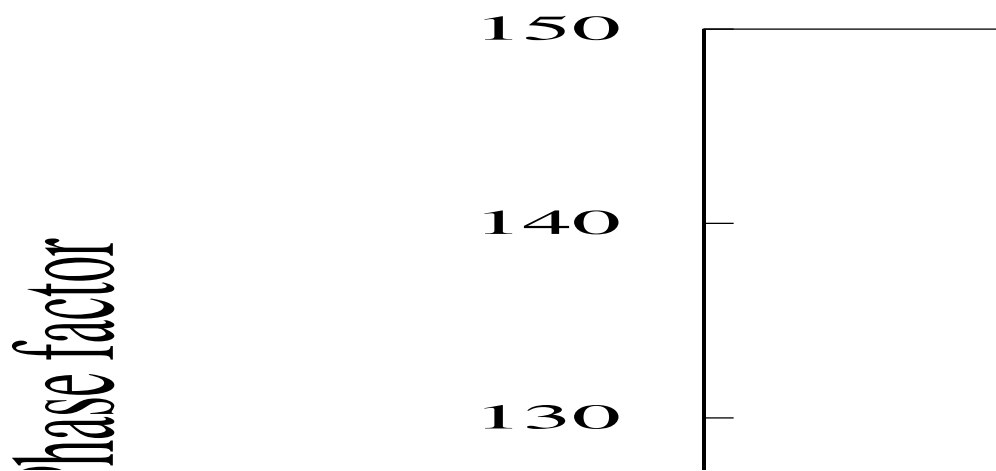
3. Results and discussion

For the calculation of Phase factor we first study the characteristics impedance, phase velocity and guide wavelength and there variation with strip geometry substrate height and frequency various computational work have been performed and results obtained are placed in table 1, 2, 3. Also various graphs have been plotted by putting the variables w, h and f on x-axis and phase factor on y axis as shown in graphs accordingly.

Table1: Variation of Phase factor with frequency (f)

h = 100 mils, t = 0.01 mils, W = 50 mils

f (GHz)	$\epsilon_r = 10.5$		
	$Z_0 (\Omega)$	$\lambda_g \times 10^{-2} \text{m}$	$\beta = 2\pi/\lambda_g$ degree
2	63.63	5.97	113.99
5	65.72	5.48	117.34
10	71.27	4.95	129.21
15	73.42	4.63	137.51
20	74.52	4.47	142.11

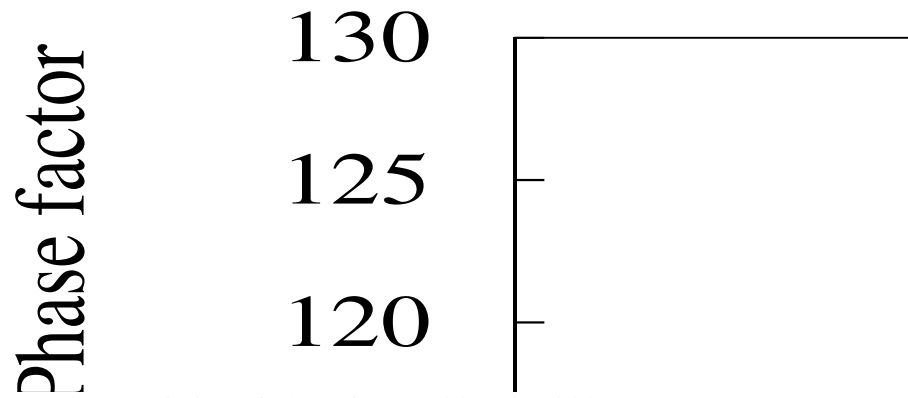


Graph 1: Variation of Phase factor with frequency (f)

Table2: Variation of Phase factor with stripwidth (w)

h = 100 mils, t = 0.01 mils, f = 2 GHz

W (mils)	$\epsilon_r = 10.5$		
	$Z_0 (\Omega)$	$\lambda_g \times 10^{-2} \text{m}$	$\beta = 2\pi/\lambda_g$ degree
50	64.30	5.59	113.98
100	48.10	5.48	114.39
150	37.20	5.34	119.52
200	33.95	5.26	121.80
250	29.75	5.17	122.98



Graph 2: Variation of Phase factor with stripwidth (w)

4. Conclusion

The variation of phase factor and propagation parameter of microstripline shows an increase with stripwidth and frequency. The rate of increase of propagation parameter with frequency is larger than the rate of increase of stripwidth. Thus propagation parameter is smaller for narrower strip and larger for wider strip. This concludes that phase factor is more useful for larger flow of power through the structure with smaller dissipation of power. But dispersion effect is smaller in lower GHz frequency range than the higher GHz range of frequency.

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